10/557190

IAP20 Rec'd PCT/PTO 18 NOV 2005

TRANSLATION (HM-657PCT):

WO 2004/104,232 A1

PCT/EP2004/004,312

METHOD FOR PRODUCING FOAMED SLAG ON HIGH-CHROMIUM MELTS IN AN ELECTRIC ARC FURNACE

The invention concerns a method for producing foamed slag on high-chromium steel melts in an electric arc furnace, wherein a mixture of a metal oxide and carbon is introduced into the furnace, the metal oxide is reduced by the carbon in the slag, and the resulting gases bring about the foaming of the slag by bubble formation.

In the operation of electric arc furnaces, the charge, i.e., mainly scrap, and alloys are melted by the electric arcs of the electrodes, which extend downward into the furnace shell. The slag fulfils not only its primary function, i.e., the removal of undesirable components from the melt, but also a protective function in the foamed state. In this state, the slag encloses the space between the ends of the electrodes and the surface of the metal and protects the refractory lining of the furnace from radiant energy of the electric arc. Due to the low thermal conductivity of the foamed slag, the radiation of

the electric arc towards the wall of the arc furnace is greatly reduced, and thus the energy input into the metal melt is improved.

In the case of nonstainless steels or steels with a low chromium content, the foamed slag is produced by simultaneous injection of carbon and oxygen onto the slag and into the steel bath, respectively. The gas that evolves during the reactions that occur:

$$2[C] + \{O_2\} \cdot 2\{CO\}$$

$$2\{CO\} + \{O_2\} \cdot 2\{CO_2\}$$

causes foaming of the slag. In addition, the carbon reduces the ferrous oxide to iron and carbon monoxide according to the equation

$$(FeO) + [C] \cdot [Fe] + \{CO\}.$$

The foamed slag encases the electrodes and is present as a protective layer between the electric arcs and the furnace wall.

In the case of high-chromium melts, the injected carbon reacts basically as a reducing element of the chromium oxide. The reactions specified above have little importance in the metal bath. Besides, the content of iron in the slag is too low to guarantee satisfactory foaming of the slag. All together, in the case of high-chromium melts, it is difficult, due to the

differences that have been mentioned, to produce a foaming slag in the superheating phase.

For this purpose, EP 0 829 545 B1, which concerns a method for producing a foamed slag on molten stainless steel in an electric arc furnace, proposes that a powder, which consists of a metal oxide, either zinc oxide or lead oxide, and carbon, be introduced into the slag. The oxide contained in the powder is reduced by reaction with the carbon. Bubbles consisting mainly of carbon monoxide are formed in the slag and cause the slag to foam. The powder is introduced into the slag with the aid of an injection medium, for example, nitrogen.

Thus, in accordance with the prior art, the reactive mixture is introduced into the slag or melt as a powder. Due to the relatively large surface area associated with the powdered form, brief, violent reactions occur. Moreover, the reaction is locally limited in the vicinity of the injection device and here especially at the tip of the injection lance in the molten bath.

Proceeding from this type of prior art, the objective of the invention is to develop a method for producing foamed slag on molten high-chromium steels in an electric arc furnace, in which the processes that initiate the foaming reaction occur in a controlled way.

This objective is achieved by a method with the features of Claim 1. Advantageous refinements of the invention are described in the dependent claims.

In accordance with the invention, the furnace is charged with a mixture of a metal oxide and carbon, not as a powder but rather as compressed preforms and/or preforms provided with a binder. In addition to the preferred pelletized form, it is possible to use other forms, for example, the briquet form. The systematic adjustment of the properties of the preforms, hereinafter referred to in terms of their embodiment as pellets, makes it possible, in contrast to use in powdered form, to control the evolution of gas with respect to location, type, and time -- especially the starting point with respect to time, the rate, the intensity of the reaction, and/or the duration of the reaction.

In particular, the density properties of the pellets are adjusted by the compression pressure and/or the type and amount of an admixed iron carrier, for example, ferronickel, and a binder. In this regard, in accordance with a preferred variant, the density of the compressed preforms is adjusted in such a way that the pellets float in the slag near or directly on the metal-slag phase boundary itself. The addition of the iron

carrier ensures that the pellets are heavier than the slag but lighter than the metal melt. The evolution of gas thus occurs in a locally well-defined way, namely, in the slag at the boundary between the metal and slag. In this way, there is no contact between pellets and metal bath, so that carburization of the melt is prevented. It is also possible to adjust the pellet properties in such a way that the pellets can occupy different positions between the molten bath and the slag. This guarantees that the processes that initiate the foaming occur only in the slag, so that the effectiveness is increased.

Furthermore, the pellets should have a density or a degree of compaction that causes them to disintegrate uniformly and slowly, so that the foaming reaction occurs uniformly and over a relatively long period of time. In addition, it is possible to cause the reactions to occur with a time delay by using even higher pressure compaction. This prevents the reaction from occurring too soon and guarantees that the reaction will not start until the pellets are distributed in the slag.

In addition, the evolution of gas can be systematically adjusted by the size of the pellets. As a result of the fact that the pellets have a relatively large diameter and thus a smaller specific surface than powders, the foaming reaction can

be maintained for relatively long periods of time with uniform gas evolution.

The basic components metal (Me) oxide and carbon are involved in the following reactions:

$$(Me_xO_n) + [C] \cdot x[Me] + \{CO\}$$

$$2\{CO\} + \{O_2\} \cdot 2\{CO_2\}$$

Waste products of steel production can be used for the mixture for producing the pellets, such as carbon from consumed electrodes or pieces of waste scale. The use of binders is advisable especially with mixtures of this type.

Aside from the basic components metal oxide and carbon, a flux, especially limestone, is additionally pressed into the proposed pelletized form. The desired CO/CO_2 formation is additionally intensified by the limestone.

Furthermore, a slag thinner, preferably CaF_2, can be additionally pressed into or bound with the mixture. This counteracts the tendency of chromium-containing slags to become increasingly viscous with increasing chromium oxide content.

It is also advisable to press a reducing agent, such as silicon and/or aluminum, into some of the pellets, especially together with limestone, to control the chromium oxide content of the slag. These reducing agents reduce the chromium oxide

contained in the slag and thus lower the chromium content of the slag. In addition, the foaming of the slag is improved.

In contrast to powder, which must be locally injected, the pellets are added in various parts of the furnace through the furnace roof and/or the sidewalls of the furnace. This is not possible with powder, because large fractions of the powder would be sucked out by the dust removal system of the furnace. It is also advisable to introduce the pellets into the slag in a directed way in the vicinity of and directly at the hot spots of the electrodes to allow the foaming process to occur especially at the electrodes.

Additional details and advantages of the invention are specified in the following description of the drawings.

-- Figure 1 shows a schematic representation of the cross section of an electric arc furnace with charging devices for the slag-foaming pellets.

-- Figure 2 shows the furnace in Figure 1 from above.

The electric arc furnace 1 shown in Figure 1 comprises a furnace shell 2 with a refractory wall 3 and a furnace roof 4. After the furnace has been charged with scrap and alloying components, three electrodes (in the present case) 5a-c are lowered into the interior of the furnace. The solid material is

melted down by the electric arcs that are produced. A slag layer 7 is formed and floats on the melt. To initiate a foaming reaction of the slag 7 between the electrodes 5a-c and the refractory furnace wall 3, slag-foaming material is introduced into the interior of the furnace as preforms 8, namely, in the form of pellets. The pellets are preferably charged through the furnace roof 4, specifically, through the fifth roof hole 9, and/or the sidewalls 10. Injection systems with injection lines or gravity feed systems 11 that extend through the sidewalls 10 of the furnace are provided for this purpose. Instead of injection lines, it is also possible to use injection lances.

Alternatively or additionally, a pneumatic conveyance system 12 consisting of closed circular pipelines is also suitable for charging the pellets. This system has a closed circular pipeline 13 that runs along the roof 4, as shown in Figure 2, which at the same time also has closed circular pipeline segments 14 that run radially to the roof. Three charging holes 15a-c (in the illustrated example) are provided in the closed circular pipelines 13, 14 and the corresponding roof wall. The pellets are introduced into the furnace slag 7 uniformly over the cross section of the furnace by this system 12. In this regard, the charging holes 15a-c are arranged in

such a way that the pellets react with the slag 7 in the vicinity of the hot spots.

The pellets float in the slag 7, where they react to produce the desired gas evolution and thus foaming reaction in a way that is controlled with respect to location, time, and type. In particular, the adjustment of the density and size of the pellets makes it possible to ensure that the gas evolution process proceeds as uniformly as possible, for a relatively long time and not too violently. A controlled reaction at the surface of the pellets results in uniform foaming of the slag.

List of Reference Numbers

1 electric arc furnace

2 furnace shell

3 refractory wall

4 furnace roof

5 electrodes

6 melt

7 slag

8 preforms (pellets)

9 fifth roof hole

10 sidewalls of the furnace

11 injection line

12 pneumatic conveyance system

13 closed circular pipeline

14 sections of closed circular pipeline

15 charging holes